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GROWTH RATE OF THE NORTHERN ANCHOVY, *ENGRAULIS MORDAX*, IN SOUTHERN CALIFORNIA WATERS, CALCULATED FROM OTOLITHS[1]

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The annual growth rate for northern anchovies in southern California waters was determined by measuring annuli formed in otoliths and then back calculating to length at time of annuli formation. The calculated mean lengths at end of each year of life were 92, 112, 124, 135, 145, and 155 mm (3.6, 4.4, 4.9, 5.3, 5.7, and 6.1 inches) SL for ages 1 through 6 respectively. A growth curve fitted by the von Bertalanffy growth equation yielded lengths of 92, 111, 125, 135, 143, and 149 mm (3.6, 4.4, 4.9, 5.3, 5.6, and 5.9 inches) SL for ages 1 through 6 respectively.

INTRODUCTION

With the decline of the Pacific sardine, *Sardinops sagax caeruleus,* the northern anchovy became one of the more important species in California fisheries. During 1969, 1970, and 1971, more tons of anchovies were taken from California waters than any other species of fish. In 1969 the spawning population in waters off California and northern Baja California was conservatively estimated to be 4.9 million metric tons, (5.4 million short tons) Vrooman and Smith 1971). This population constitutes one of the major forage species in California waters (Pinkas et al. 1971) and supports a viable reduction (fish meal) fishery and a live bait fishery.

Samples from anchovy landings have been collected since 1946, and many authors have reported on the length distribution of year classes; however, mean lengths at age give little insight into annual growth rates. What is really meant when speaking of length at age is *mean* length at *mean* age. The problem is that mean age is not known precisely enough to compare a series of yearly data to determine annual growth rates. Clark and Phillips (1952) estimated annual growth rates for northern anchovies in California. They collected scale samples from anchovies in Monterey Bay and back calculated to length at age by measuring annuli formed on scales. My study was undertaken to determine if the growth rate of anchovies has changed since Clark and Phillips conducted their study.

METHODS AND PROCEDURES

Sampling Methods

With the inception of the anchovy reduction fishery in 1965, the California Department of Fish and Game began intensively sampling San Pedro anchovy landings for age and size composition as part of an extensive program to monitor the fishery. Collins (1969) described in detail the sampling plan that was developed. By the end of the 1971–

[1] Accepted December 1974.

72 anchovy reduction season, over 22,000 pairs of otoliths had been collected for determining the age composition of San Pedro landings.

Collins and Spratt (1969) indicate peak time of ring formation in otoliths is late spring and that by June 1st nearly all otoliths show a newly completed annual ring. For this reason, I decided to consider only anchovies sampled in April and May (period of peak ring formation) during each of the seven anchovy seasons.

Samples collected from San Pedro anchovy reduction landings during the spring from 1966 to 1972 were used with the exception of 1968.

TABLE 1. Length Distribution by Age at Time of Capture

mm SL	Age group 1	2	3	4	5	6
160					1	
158					--	2
156					3	
154				1	3	
152				1	3	
150				1	3	
148				3	--	
146				3	3	
144			2	6	1	
142			5	5	1	
140			3	5	1	
138		1	6	8	1	
136		6	15	5		
134		5	8	2		
132		3	17	5		
130		8	12	2		
128		11	18	1		
126		14	11	1		
124	2	21	9			
122	5	22	10			
120	6	22	6			
118	14	27	2			
116	19	27	1			
114	19	25	--			
112	22	15	--			
110	32	13	1			
108	34	7				
106	26	2				
104	22	1				
102	22	1				
100	7	1				
98	5					
96	3					
94	5					
92	1					
90	1					
88	3					
86						
Number	248	232	126	49	20	2
$\bar{x}$ Length in mm (inches)	109 (4.3)	119 (4.7)	130 (5.1)	140 (5.5)	150 (5.9)	158 (6.2)

During 1968 the anchovy live bait catch in southern California was sampled (Crooke 1969), and I included otoliths from these samples in the study. Otoliths were taken from anchovies collected at sea in southern California aboard the Department's research vessel *Alaska* during the spring of 1972 and these also were included in the study. In all, I examined 2,856 pairs of anchovy otoliths collected during routine sampling of spring anchovy reduction landings in southern California, 210 pairs of otoliths from the 1968 live bait landings, and 200 pairs collected aboard the *Alaska* during 1972.

While a total of 3,266 pairs of otoliths was examined, only 677 pairs were accepted for use in this study. These fish ranged in length from 88 to 160 mm (3.5 to 6.3 inches) standard length (SL) and were from 1 to 6 years old (Table 1).

The following criteria were followed in otolith selection: (i) agreement in age assignment between original reader and myself; (ii) the most recently formed annual ring must be on the margin of the otolith; (iii) no false annuli may be present. Otoliths from samples were all aged by one reader. I examined these again, and only those otoliths whose age the original reader and I agreed upon were used in this study.

Age and year class were assigned to all fish using the method described by Collins and Spratt (1969). A ring or annulus is defined as the interface between an inner hyaline and an outer opaque zone, and it is often difficult to determine if the most recent ring is on the otolith

Method of Measuring Otoliths

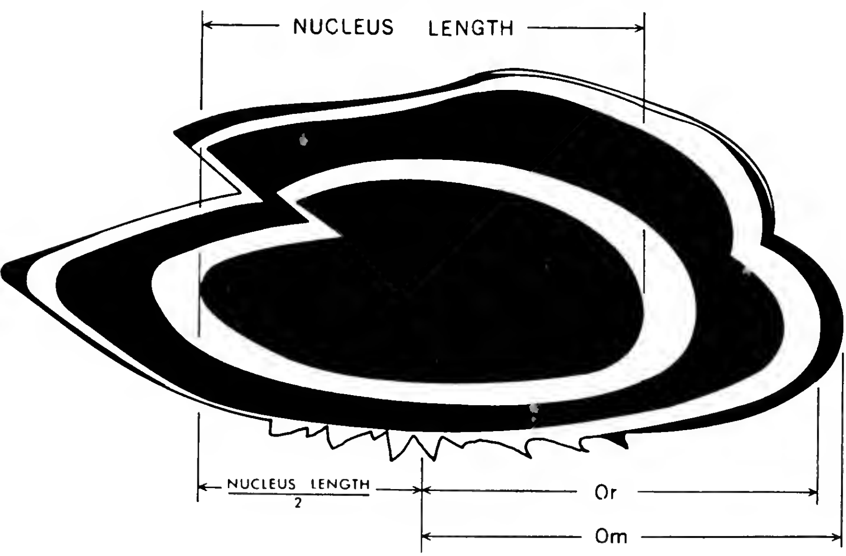

FIGURE 1. Diagram of a hypothetical otolith from a 2-year-old anchovy showing where measurements were taken. Black indicates opaque areas. The second annual ring is considered to be on the margin. Measurement: Or—distance from center of nucleus to most recent annuli; Om—distance from center of nucleus to otolith margin.

margin. New growth is first evident on the dorsal edge and antirostrum of the otolith (Collins and Spratt 1969). When these areas are opaque (Figure 1), the most recent ring is considered to have just formed and to be on the margin.

It was unnecessary to measure the distance each annual ring was from the center of the otolith, due to the large number of otoliths available. Instead, only two measurements were made on each otolith; one from the center of the nucleus to the most recently formed annulus (interface between inner hyaline and outer opaque zones), and one measurement from the nucleus center to the otolith margin (Figure 1). Both measurements were made with an occular micrometer at 30 magnifications on a line from the center of the nucleus to the farthest posterior point on the otolith.

Length Calculations

Sampling methods made it possible to follow an individual year class through successive years and examine otoliths representing that year class during periods of annual ring formation. It is possible to determine fish length at the end of each year of life by back calculating the length of the fish at the time the most recent annulus was formed.

The conventional method of back calculating is to use older fish and measure each annulus formed on scales or calcified body parts to estimate length at the end of each year of life. Measuring each annual ring on a five ring otolith would involve a time span of 4 years in back calculating. I chose not to use this method because it may introduce an unknown degree of error. When using scales, the further back one calculates the greater the difference between calculated lengths and observed lengths. This is known as Lee's Phenomenon and a similar problem probably exists with otoliths. Any inherent error in my method is minimized because back calculations involve a time span of a few months at most

A direct proportion between otolith measurements and length at time of capture was used in back calculating. The relationship between otolith length and standard length of the fish is linear (Figure 2). The formula used in back calculating is:

$$L = \frac{(L+)(Or)}{Om}$$

where

L = length at time of ring formation
I+ = length at time of capture
Or = distance from center of nucleus to most recently formed ring
Om = distance from center of nucleus to the otolith margin.

As an example, the 1965 year class is represented by one ring fish in May 1966, by two ring fish in May 1967, and so on until the 1965 year class disappears from samples. Data are then available to make a separate back calculation for each year the year class was sampled. Each back calculation involves measurements of only the most recently formed annuli.

The back calculated lengths for age groups 1 through 6 were fitted to the von Bertalanffy growth curve by the equation:

$$l_t = L_\infty[1 - e - K(t - t_o)]$$

where

t = age in years
l_t = mm SL at age t
L_∞ = asymptotic length
K = a constant proportional to the coefficient of catabolism
t_o = hypothetical age at zero length.

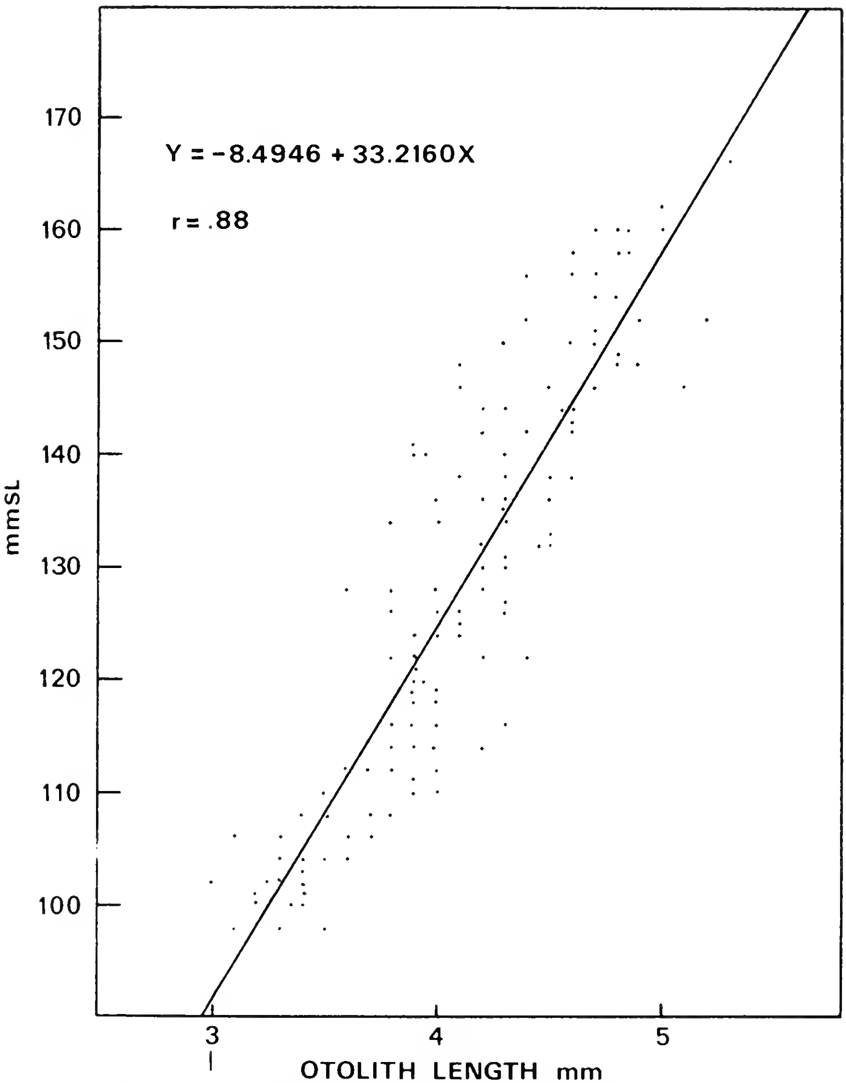

FIGURE 2. Relationship between otolith length and standard length.

TABLE 2. **Calculated Length Distribution by Age at End of Year of Life**

mm SL	Age group 1	2	3	4	5	6
156	----------	----------	----------	----------	----------	1
154	----------	----------	----------	----------	1	1
152	----------	----------	----------	----------	1	
150	----------	----------	----------	1	5	
148	----------	----------	----------	--	2	
146	----------	----------	----------	2	4	
144	----------	----------	----------	2	--	
142	----------	----------	----------	3	2	
140	----------	----------	----------	3	2	
138	----------	----------	----------	5	1	
136	----------	----------	8	7	1	
134	----------	----------	1	8	1	
132	----------	----------	8	1		
130	----------	----------	6	10		
128	----------	3	17	2		
126	----------	4	16	2		
124	----------	5	15	2		
122	----------	9	16	1		
120	----------	15	12			
118	----------	16	8			
116	----------	19	7			
114	----------	26	7			
112	1	31	3			
110	1	28	--			
108	3	24	1			
106	6	15	--			
104	8	19	--			
102	13	4	1			
100	14	5				
98	21	2				
96	21	3				
94	28	3				
92	20	1				
90	18					
88	15					
86	27					
84	13					
82	16					
80	12					
78	4					
76	3					
74	1					
72	2					
70	--					
68	--					
66	1					
Number	248	232	126	49	20	2
$\bar{x}$ Length in mm (inches)	92 (3.6)	112 (4.4)	124 (4.9)	135 (5.3)	145 (5.7)	155 (6.1)
99% Conf. Interval	±1.32	±1.18	±1.49	±2.38	±3.56	--

RESULTS

California Cooperative Oceanic Fisheries Investigations (CalCOFI) egg and larva surveys by National Marine Fisheries Service have found anchovy larvae during every month of the year (Ahlstrom 1966). This year-round spawning activity is reflected in the wide range of calculated lengths at age (Table 2). The exact age of two fish with the same number of annuli may actually be several months apart due to the protracted spawning period. The growth rate of individual year classes

TABLE 3. Back Calculated Mean Standard Length at End of Each Year of Life for Every Year Class in the Study.

Year class	End of year of life					
	1	2	3	4	5	6
1960	----------	----------	----------	----------	148 (1)	156 (1)
1961	----------	----------	----------	137 (4)	146 (7)	
1962	----------	----------	123 (17)	137 (10)	143 (1)	154 (1)
1963	----------	113 (26)	126 (13)	135 (*)	145 (*)	
1964	91 (20)	116 (16)	124 (*)	134 (9)	147 (1)	
1965	101 (4)	114 (5)	126 (17)	134 (5)	148 (7)	
1966	90 (16)	112 (43)	123 (35)	137 (6)	146 (2)	
1967	97 (35)	116 (20)	128 (16)	135 (13)		
1968	93 (110)	116 (15)	128 (27)			
1969	90 (35)	110 (107)				
1970	88 (28)					
Grand mean length in mm (inches)	93 (3.7)	114 (4.5)	125 (4.9)	135 (5.3)	146 (5.7)	155 (6.1)
Number	(248)	(232)	(126)	(49)	(20)	(2)
99% Conf. interval	±1.1	±.6	±.6	±.7	±1.5	

* Insufficient data and mean value substituted.

also may be affected by environmental changes during their early life history, when they have an accelerated growth rate. For these reasons, the length at end of each year of life for every year class sampled is presented separately (Table 3). The data show variability between mean lengths of different year classes at the same age is low. This indicates environmental factors that may affect growth rates have had little effect over the past 7 years.

With the fitted constants (Table 4) the von Bertalanffy growth equation yields lengths at age (Table 5) which compare closely with back calculated mean length at age. The curve obtained (Figure 3) uses all observations available and is heavily weighted to the ages for which there were more observations. I am much more confident of the growth estimates for ages 1 and 2 than ages 5 and 6, where there were fewer observations.

TABLE 4. Constants and Standard Errors for von Bertalanffy Growth Equation

	L_∞	K	t_o
Estimate	165.52	.298682	−1.7144
Standard Error	5.52	.032997	.1752

TABLE 5. Comparison of Length Derivation by von Bertalanffy Growth Equation and Back Calclating.

End of year	Standard length at age (mm)	
	von Bertalanffy	Back calculating
1	92	92
2	111	112
3	125	124
4	135	135
5	143	145
6	149	155

The asymptotic length, 166 mm (6.5 inches) SL agrees with observed data. During seven seasons of sampling anchovy landings at San Pedro, only one fish longer than 166 mm (6.5 inches) SL was sampled; it measured 169 mm (6.6 inches) SL.

The annual growth increment (Table 6) levels off at a rate of about 1 mm per month in fish over 2 years old. This does not agree with Clark and Phillips (1952) (Table 7). Our data are from the same subpopulation of anchovies which extends from Northern Baja California to central California (M. Vrooman, pers. comm.; Spratt 1972).

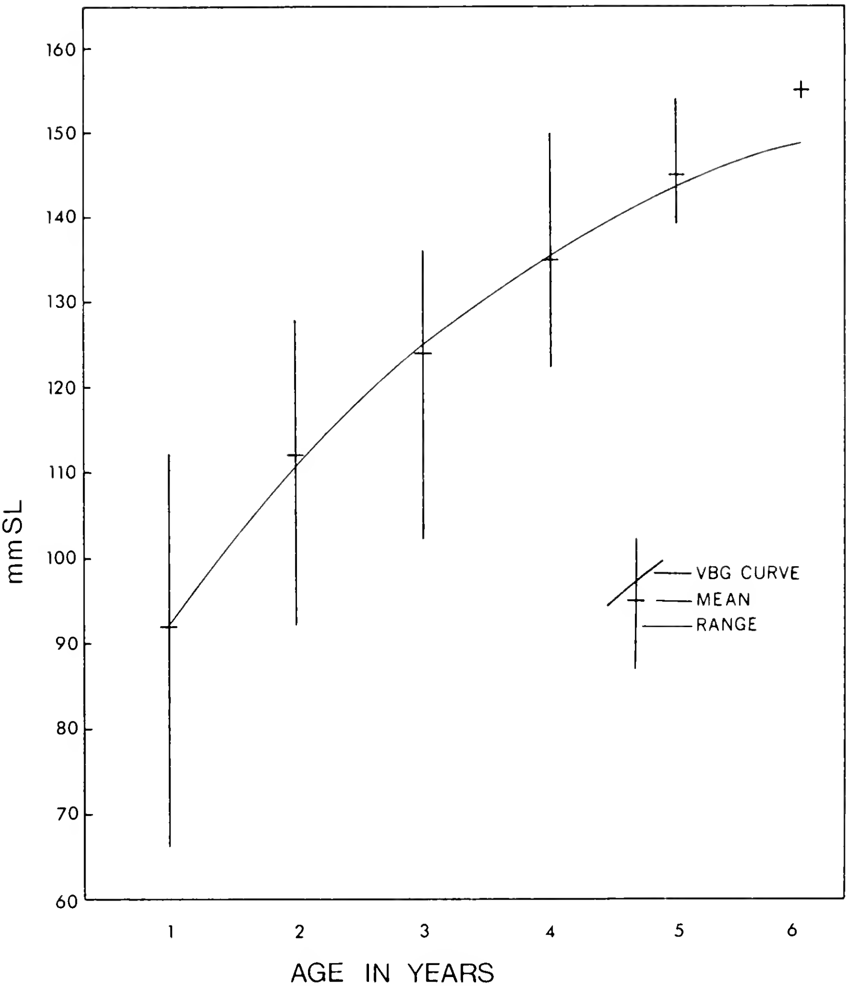

FIGURE 3. Calculated length distribution by age and the fitted von Bertalanffy growth curve.

TABLE 6. Annual Growth Increment for Anchovies in Southern California

At end of year	Calculated standard length (mm)	Annual growth increment (mm)
1	92	92
2	112	20
3	124	12
4	135	11
5	145	10
6	155	10

TABLE 7. **Annual Growth Increment for Anchovies in Central California from Clark and Phillips (1952).**

End of year	Standard length (mm)	Annual growth increment (mm)
1	92	92
2	120	28
3	139	19
4	152	13
5	161	9
6	167	6
7	171	4

DISCUSSION

The anchovy population in southern and central California has increased dramatically since 1952, when Clark and Phillips concluded their study (Vrooman and Smith 1971).

Samples taken from the anchovy reduction fishery from 1965 to 1972 in southern and central California show that mean length is smaller in southern California (Collins 1969, 1971; Spratt 1972b, 1973a, 1973b). The size difference may be related to the anchovy population increase which was more pronounced in southern California.

Knaggs and Parrish (1973) indicate that the decrease in the population size of Pacific mackerel, *Scomber japonicus,* may have resulted in an increase in weight at length and maturation at an earlier age. MacGregor (1959) also found an inverse relationship in Pacific sardine between condition factors and population size. Accordingly, the increase in the anchovy population size which would cause increased competition among individual fish could result in a slower growth rate.

The populations of all three species, Pacific mackerel, Pacific sardine, and northern anchovy have fluctuated dramatically in recent years. All three species exhibit density dependency. If anchovies are density dependent, then this could account for slower growth rates when the population increased to its present level.

CONCLUSIONS

The growth rate of northern anchovies has changed after the population underwent a dramatic increase in the late fifties and early sixties.

Current data indicate that the mean length at end of each year of life is 92, 112, 124, 135, 145, and 155 mm (3.6, 4.4, 4.9, 5.3, 5.7, and 6.1 inches) SL for ages 1 through 6 respectively. A growth curve fitted by the von Bertalanffy growth equation yielded lengths of 92, 111, 125, 135, 145, and 149 mm (3.6, 4.4, 4.9, 5.3, 5.6, and 5.9 inches) SL for ages 1 through 6 respectively.

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Calif. Fish and Game, 61(3): 127–132. 1975.

MORTALITY AND GROWTH RATES, COST, AND RELATIVE CONTRIBUTION OF TWO DIFFERENT SIZES OF SILVER SALMON STOCKED IN LAKE BERRYESSA, CALIFORNIA, IN 1972[1]

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Tagged silver salmon stocked in Lake Berryessa, Napa County, California, showed nearly identical mean annual exploitation and survival rates, 0.38 and 0.18 when compared to 1970 and 1971 experiments. Total harvest (0.46) was slightly higher. Growth ultimately achieved in this experiment amounted to 1.65 kg (3.64 lb) after approximately 18 months in the lake and showed an increase of 0.23 kg (0.50 lb) over 1971. Cost to the angler's creel ($1.53/kg) also increased, but resulted from increased hatchery production costs. Anglers caught 213.1% of the originally planted weight, consistent with previous findings. Fish planted in March contributed equally to the catch and confirmed previous findings that silver salmon under certain conditions can be planted at a smaller size or earlier in the year than rainbow trout and still make a valuable contribution to a limnetic fishery. Their role and criteria for selection in a given water are also discussed.

INTRODUCTION

Results of previous experiments with stocked silver (coho) salmon (*Oncorhynchus kisutch*) at Lake Berryessa showed these fish could be planted at small size (45 to 57g) (1.6 to 2.0 oz), but tagging did not accurately measure their true contribution to the fishery because of post-tagging mortality (Wigglesworth and Rawstron 1974). Cost to rear salmon to 203 to 254 mm (8 to 10 inches) is estimated to be double that for rainbow trout (*Salmo gairdneri*) of the same size (William E. Schafer, Calif. Dept. of Fish and Game, pers. comm.). The chief reason for this additional cost is that silver salmon are 18 months old when planted in May while domestic rainbow trout strains are typically 10 to 14 months old. Slower-growing salmon also occupy pond space which could be used for additional production of spring spawning rainbow and, therefore, interfere with the hatchery's capability to rear catchable rainbow trout.

Therefore, this study was designed to (1) determine the exploitation, survival, growth rates, and cost to the angler's creel of silver salmon as the last of a series of experiments; and, (2) compare the relative contribution to the fishery of members of the same cohort of salmon raised in a single hatchery and stocked in March and May. The experiment was conducted at Lake Berryessa, Napa County. This lake and certain portions of its fishery have been described by Rawstron (1972, 1973*b*), Wigglesworth and Rawstron (1974), Rawstron and Reavis (1974).

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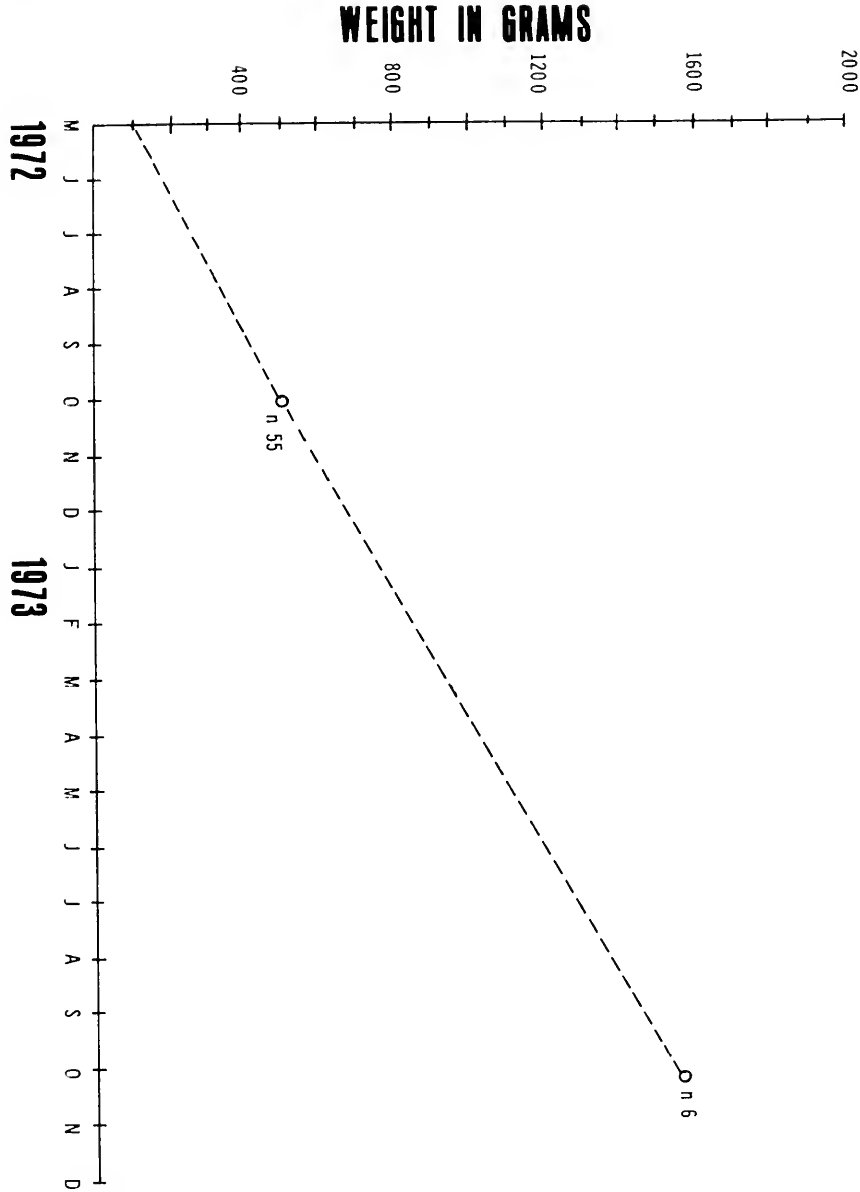

FIGURE 1. Growth rate of tagged silver salmon planted in Lake Berryessa, 1972.

METHODS AND MATERIALS

A total of 20,000 silver salmon was stocked. The first group of 10,000 was stocked on March 22, 1972 and marked by removal of the adipose fin. The remainder were stocked on May 15, 1972 and were unmarked. In addition, 200 from the latter group were tagged with trailer tags (modified Carlin) offering $5 for their return. This tag has been widely used on salmonids in California and has proven efficient (Rawstron 1973*a*; Wigglesworth and Rawstron 1974). The tag and method of application has been thoroughly described by Nicola and Cordone (1969). Public acceptance and awareness of this program has remained at a high level since experiments with salmonids began in 1968. Therefore, all tags were assumed to be returned for the reward.

Darrah Springs Hatchery (Shasta County) reared all the fish used in this experiment to their final planting size. Fertilized eggs obtained from salmon ascending the Alsea River drainage, Oregon, were initially brought to Mt. Shasta Hatchery (Shasta County) and reared in water temperatures of 2 to 10 C (36 to 50 F) into late summer and then transferred to Darrah Springs Hatchery where temperatures were near 14 C (57 F). This procedure slowed early growth and provided fish of 16 to 18 months for these experiments.

Salmon stocked in March had a mean weight of 64g (0.14 lb) and a mean fork length of 188 mm (7.4 inches). The untagged fish planted in May averaged 76g (0.17 lb) with a mean fork length of 201 mm (7.9 inches). Tagged fish had a mean weight of 126g (0.28 lb) and a fork length of 218 mm (8.6 inches).

A creel survey conducted on several weekends in both October 1972 and October 1973 provided estimates of mean weight for each group as well as their relative contributions. Total weight of tagged fish ultimately harvested was estimated by multiplying estimated monthly weight obtained from a line connecting the mean weights derived in the surveys by the number of tags returned during that month and summing the calculated landed monthly weights.

Survival and weighted exploitation rates were estimated, using Ricker's (1958) method, from angler returns of the reward tags. First year returns were considered to be those tags returned from fish caught 0 through 365 days after tagging. Second year returns were those from fish captured 366 through 730 days. Since the typical life cycle of these fish is complete after three years, returns were considered complete after January 1, 1974, when all fish were presumed to have reached sexual maturity.

RESULTS

Mortality and Survival

Anglers harvested a total of 91 tagged salmon during the experiment (Table 1). This amounted to a total harvest rate of 0.46. Of fish harvested only 25 (27.5%) were harvested before they had made appreciable weight gains (May–September) (Table 1). Mean survival rate amounted to 0.18 based on 77 first year and 14 second year returns. Weighted mean annual exploitation rate was 0.38.

Growth, Weight Returns, and Cost

Fifty-five salmon weighed in the creel survey in October 1972 averaged 0.49 kg ± 0.04 kg ($\alpha = 0.05$) (1.08 lb ± 0.09 lb) while six weighed in October 1973 had a mean weight of 1.65 kg (3.64 lb) (range 1.31 kg to 1.99 kg) (Figure 1). Weighted estimate of the average weight of individual fish landed amounted to 0.59 kg (1.30 lb).

Anglers landed an estimated 53.7 kg (118.4 lb) of tagged fish. Total weight at planting amounted to 25.2 kg (55.6 lb). The percentage of weight returned to weight planted was 213.1%. Doubling the cost of \$1.63/kg (\$0.74/lb) (Bruley and McClendon 1973) to produce rainbow trout of equivalent size, these fish then cost \$1.53/kg (\$0.69/lb) in the angler's creel.

TABLE 1. Tag Returns Through January 31, 1974 by Month and Year of Tagged Silver Salmon Planted in Lake Berryessa, May 15, 1972.

Period	Number Returned	
	Year 1 1972–73	Year 2 1973–74
May 15–30	4	3
June	8	3
July	3	4
August	2	0
September	8	0
October	10	1
November	16	2
December	9	0
January	3	1
February	2	
March	5	
April	5	
May 1–14	2	
Total	77	14

Relative Contribution

In October 1972 survey clerks saw 104 untagged silver salmon from the March plant and 101 from May. Mean weight of 31 of the former group was 0.49 kg ± 0.03 kg (1.0 lb ± 0.06 lb) while 24 of the latter averaged 0.51 kg ± 0.04 kg (1.1 lb ± 0.08 lb). No significant difference in weight ($\alpha = 0.05$) existed between the two groups. Since each group contributed equally to the fishery, I concluded that untagged members of both groups also suffered similar mortalities.

Yield

Assuming that untagged fish were harvested at the same rate as tagged fish, anglers landed 9,200 salmon during the study. This 8,094 hectare (20,000 acre) lake yielded 5428 kg (11969 lb) at 0.67 kg/hectare (0.60 lb/acre).

DISCUSSION

Mean annual exploitation rate (0.38) was nearly identical to that of the two previous experiments, 0.38 in 1970 and 0.39 in 1971 (Wigglesworth and Rawstron 1974). Survival rate (0.18), however, increased moderately from 0.13 and 0.17 in 1970 and 1971, respectively. Cost to the angler's creel, \$1.53/kg (\$0.69/lb), was up from \$1.26/kg (\$0.57/lb) reported in 1971 and resulted from the higher hatchery rearing costs.

Salmon planted in 1972 achieved 1.65 kg (3.6 lb), which was substantially better than those planted in 1971. In 1971 their ultimate growth up to the time of sexual maturity was only 1.23 kg (2.7 lb) (Wigglesworth and Rawstron 1974). This undoubtedly resulted from a higher population of overwintering threadfin shad upon which salmon actively feed (*ibid.*). These authors postulated that salmon growth in California's inland reservoirs is directly linked to the abundance of adult shad during winter and early spring. These populations, moreover, have been shown to be highly variable from year to year (von Geldern 1971). During winters of large holdovers of adult shad, silver salmon demonstrate increased growth.

Introduction of silver salmon as early as March appears to be a good management technique. This experiment confirms previous findings that silver salmon can be planted at a substantially smaller size than rainbow trout and still provide economical fisheries. Earlier planting also provides additional pond space needed to increase growth rates of rainbow trout that may be crowded or for transferring younger fish from rearing troughs. However, silver salmon exhibit strong smolting tendency during this period which may prevent introducing them this early in some years in some waters. Many reservoirs in California are approaching their peak surface elevations at this time and may spill. Under these conditions, salmon may leave the reservoir in large numbers. Each year conditions differ, therefore, the manager should be alert to water conditions prevailing on the reservoir for which he is considering this type of management.

The use of silver salmon in inland waters as a widespread management tool to improve limnetic fisheries should be approached cautiously. On the positive side is their ability to utilize adult threadfin shad during the winter and grow rapidly during this period when rainbow trout growth is suppressed (Rawstron 1972, 1973*b*). Salmon consistently yield approximately 200% of their planted weight to the fishery and, even at twice the production costs, are economical to plant. This consistency may be a boon to the harried manager who has many waters to manage. Their low vulnerability during the first few months after planting and their strong contribution to a trophy fishery is also an asset. In addition, they provide diversity in angling experience and have been well received by anglers. Their habit of remaining in water less than 10–13 C (50 to 55 F) affords deep trollers and fishermen drifting minnows an opportunity to capture these fish selectively during the fall when rainbow trout are surface feeding. Certain benefits may accrue to largemouth bass recruitment if abundances of adult shad, which von Geldern (1971) showed had a detrimental effect on young bass, would be reduced. On the negative side is the presently high cost of rearing them and the length of time required to get them to the

proper size for planting. Except for initial planting in lakes with shad where salmon did not previously exist, they have not realized their full potential for growth (Wigglesworth and Rawstron 1974) as evidenced from marine environments. Moreover, growth rate is only slightly better than that of domestic rainbow trout which are cheaper to rear and reach 20 to 25 mm (0.8 to 1 inch) in 10 to 14 months in the hatchery. In summary, with the exception of waters where stocking of domestic rainbow trout has been ineffective in creating a fishery in spite of suitable limnological conditions for salmonids, the use of silver salmon in a given body of water should be critically examined. Factors such as water level fluctuation patterns, initial cost of production, and lack of abundant suitable forage may preclude their use; however, if they do prove useful to management, then they should be afforded a higher priority in hatchery production schedules.

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AGE AND LENGTH COMPOSITION OF NORTHERN ANCHOVIES, *ENGRAULIS MORDAX*, IN THE 1972–73 SEASON CALIFORNIA ANCHOVY REDUCTION FISHERY[1]

by

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A total of 68,510 metric tons (75,519 short tons) of anchovies was caught in the California reduction fishery during the 1972–73 season. Data analysis indicated a dominance of age-group II (1970 year class) with large numbers of age-group I in southern California. Central California anchovy age composition was dominated by age-groups III and IV.

INTRODUCTION

This is the sixth in a continuing series of reports on the age and length composition of anchovies landed for reduction in California. The data consist of samples collected during the 1972–73 season (September 15, 1972, through May 15, 1973, in southern California and August 1, 1972, through May 15, 1973, in central California). The methods of sampling and determining age are the same as used by Collins (1971). The two fishing zones yielded 68,510 metric tons (MT) (75,519 short tons), of which 88% was landed at San Pedro, 11.5% at Port Hueneme, and 0.5% at Moss Landing (Table 1).

TABLE 1. **Anchovy Landings by Port During 1972–73 Season**

Port	Metric tons	Percent of total
Southern California		
San Pedro	60,369	88.1
Port Hueneme	7,799*	11.4
Central California		
Moss Landing	342	0.5
Total	68,510 (75,519 short tons)	100.0

* 1792 metric tons were reported caught in northern zone.

Estimated numbers by length, by year class, and by weight were calculated only from samples taken at San Pedro because there were insufficient data from the central California fishery. A total of 420 samples was taken and 6,037 fish were processed.

[1] Accepted December 1974.

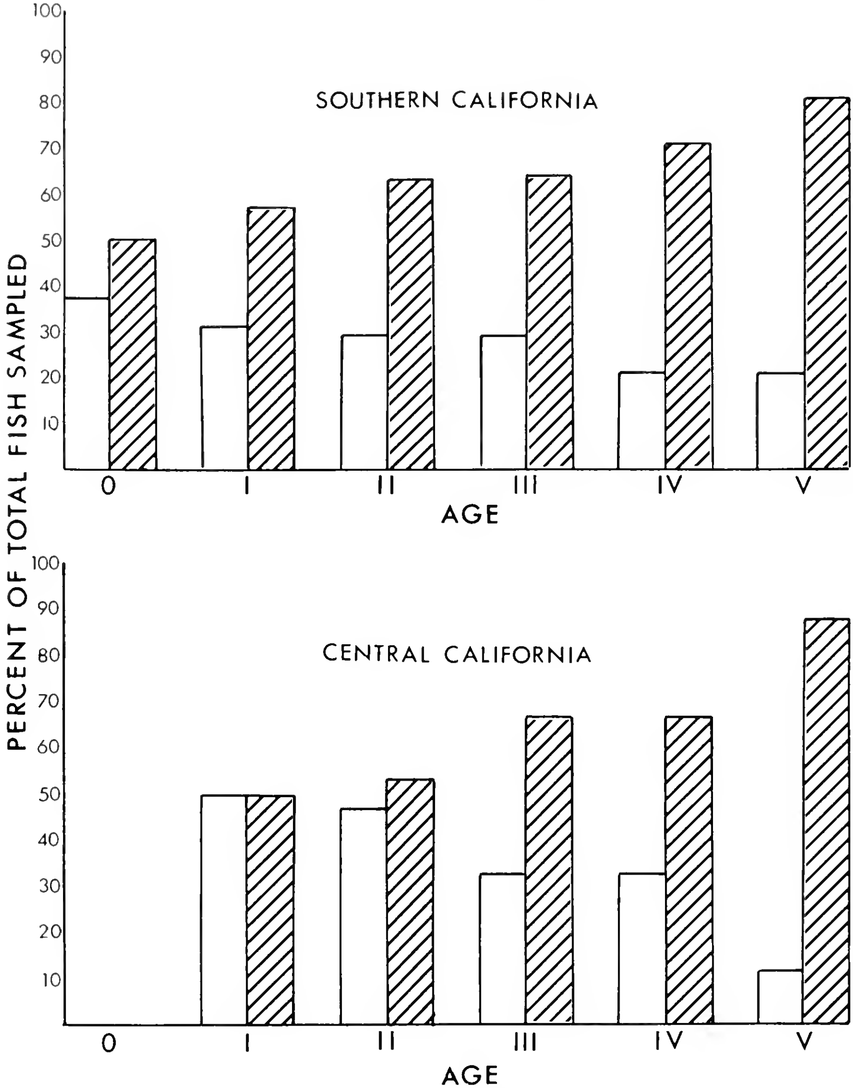

FIGURE 1—Percentage of northern anchovy males and females by age group from the 1972–73 anchovy season, (males—open figures; females—barred figures).

TABLE 2. **Mean Length (mm SL) of Year Classes in the Southern California Reduction Fishery by Stratum**

	Year class (age)								Overall mean length
	1972 (0)	1971 (I)	1970 (II)	1969 (III)	1968 (IV)	1967 (V)	1966 (VI)	1965 (VII)	
Stratum I taken 9/29/72–10/16/72	105	109	116	122	139	--	--	--	115
Stratum II taken 10/16/72–11/1/72	103	111	117	122	135	--	--	--	116
Stratum III taken 11/1/72–11/7/72	112	113	117	122	132	144	--	--	117
Stratum IV taken 11/7/72–11/14/72	107	114	119	123	131	134	147	--	120
Stratum V taken 11/14/72–12/18/72	102	104	112	119	136	--	--	--	110
Stratum VI taken 12/19/72–4/5/73	105	109	117	124	140	131	--	--	115
Stratum VII taken 4/5/73–4/10/73	111	119	127	136	142	147	162	172	132
Stratum VIII taken 4/10/73–4/16/73	113	115	121	127	141	147	--	--	120
Stratum IX taken 4/16/73–4/26/73	109	116	120	127	140	147	--	--	120
Stratum X taken 4/26/73–5/1/73	110	113	118	124	133	146	--	--	117
Stratum XI taken 5/1/73–5/6/73	107	110	116	122	128	145	--	--	115
Stratum XII taken 5/6/73–5/11/73	105	109	114	120	132	131	--	--	111
Stratum XIII taken 5/11/73–5/15/73	104	107	112	119	129	--	--	--	109
Stratum XIV taken 5/15/73	105	109	115	117	130	--	--	--	112
All strata	107	110	117	124	137	142	154	172	116

THE FISHERY

Cannery prices paid to fishermen began at $24.00/ton, but with the increased shortage of fish meal, the price for anchovies rose to $47.50 late in the season.

The anchovy fleet was comprised of 34 boats with a daily catch capacity of about 3,175 MT (3,500 short tons) per day; but under normal conditions, the processing capacity was 1,451 MT (1,600 short tons) per day, thus limiting the landings by the fishermen. Considerable fishing effort was expended in the spring when good weather and higher prices prevailed.

LENGTH COMPOSITION

Southern California

Anchovies sampled at San Pedro ranged from 80–172 mm SL (3.1–6.7 inches). Mean length of the total sampled catch was 116 mm SL (4.6 inches); although during the season, the mean length for a stratum (a unit consisting of 5,000 short tons, each unit containing 30 samples of 250 g or 1.1 lb) ranged from 110 mm SL in November–December to 132 mm SL in April (Table 2).

Anchovies 105–124 mm SL comprised 70% of the estimated 3.5 billion fish landed at San Pedro (Table 3), while the same length group for the 1971–72 season amounted to only 45%. The percentage of fish larger than 125 mm SL for the 1972–73 season was only 17% compared to 22.7% during the 1971–72 season.

TABLE 3. **Estimated Number of Anchovies by Length Group Landed at San Pedro During 1972–1973 Season.**

Length group (mm SL)	Estimated number	Standard deviation	Percent of landings
75–84	751,640	577,582	0.02
85–94	25,600,746	13,548,546	0.72
95–104	419,243,515	66,562,930	11.87
105–114	1,280,240,501	52,322,571	36.27
115–124	1,203,053,110	88,293,279	34.08
125–134	429,701,626	27,048,831	12.17
135–144	135,357,116	12,277,635	3.83
145–154	31,724,935	5,664,407	0.89
155–164	3,264,470	1,434,660	0.09
165–174	538,441	962,682	0.01
Total	3,529,476,100	--	99.94

Length at age data indicate a 3–8 mm decrease in the size of age-groups I, II, III, and IV, as compared to the same age groups for the 1971–72 season. As previously noted by Spratt (1973b), smaller but older fish were more numerous in recent years (Table 4). Females were slightly larger than males in most of the year classes (Table 5).

Central California

Because of low landings, computations for approximate numbers and weight by year classes were not made; however, length-age data were derived from samples taken. Anchovies from central California ranged from 119–168 mm SL. Approximately 85% of the fish were 135–168 mm (5.6–6.7 inches) SL, as compared with 28% during the previous season (Spratt 1973*b*). Mean lengths at age for age-groups I, II, and III also were 6–11 mm larger than the same groups for the 1971–72 season (Spratt 1973*b*).

TABLE 4. **Anchovy Mean Standard Length (mm SL) at Each Age Landed at San Pedro**

Seasons	Age 0	I	II	III	IV	V	VI	VII
1965–66								
Year class	1965	1964	1963	1962	1961	1960	1959	1958
Mean length	101	116	118	129	137	139	146	--
1966–67								
Year class	1966	1965	1964	1963	1962	1961	1960	1959
Mean length	100	115	122	131	140	141	153	--
1967–68								
Year class	1967	1966	1965	1964	1963	1962	1961	1960
Mean length	--	--	--	--	--	--	--	--
1968–69								
Year class	1968	1967	1966	1965	1964	1963	1962	1961
Mean length	112	117	125	132	138	144	146	--
1969–70								
Year class	1969	1968	1967	1966	1965	1964	1963	1962
Mean length	106	119	127	136	143	146	151	--
1970–71								
Year class	1970	1969	1968	1967	1966	1965	1964	1963
Mean length	109	120	129	135	146	152	147	--
1971–72								
Year class	1971	1970	1969	1968	1967	1966	1965	1964
Mean length	103	113	120	132	136	138	--	--
1972–73								
Year class	1972	1971	1970	1969	1968	1967	1966	1965
Mean length	107	110	117	124	137	142	154	172

AGE COMPOSITION OF THE CATCH

Otoliths were used for age determination, and year class assignments were made using the methods described by Collins and Spratt (1969).

Southern California

The 1972–73 season catch was dominated by age-group II fish, comprising an estimated 48% by number and 48% by weight of the San Pedro landings (Table 6). Age-group II was the dominant year class

TABLE 5. **Mean Length (mm SL) of Males and Females Landed at San Pedro by Year Class**

	Year class (age)								Mean length for all year classes
	1972 (0)	1971 (I)	1970 (II)	1969 (III)	1968 (IV)	1967 (V)	1966 (VI)	1965 (VII)	
Males									
Mean length	106	109	116	123	135	141	--	172	114
Females									
Mean length	108	111	118	125	138	143	152	--	117
Unknown									
Mean length	104	107	113	118	134	--	--	--	110

TABLE 6. Estimated Weight and Number of Anchovies by Year Class Landed at San Pedro for Reduction i Southern California During 1972–73 Season.

	Year class (age)								
	1972 (0)	1971 (I)	1970 (II)	1969 (III)	1968 (IV)	1967 (V)	1966 (VI)	1965 (VII)	Total
Kilograms	4,696,021	13,297,296	28,549,875	10,447,912	2,339,930	435,579	44,086	31,377	59,842,037 (131,929,800 pounds)
Standard deviation	762,586	667,348	1,079,559	522,540	358,251	125,394	33,016	56,027	--
Percent	7.84	22.22	47.70	17.45	3.91	0.72	0.07	0.05	99.96
Number	334,073,345	915,832,738	1,679,415,627	502,612,844	81,728,120	14,113,237	1,161,748	538,441	3,529,476,100
Standard deviation	51,314,853	42,419,046	52,618,971	25,468,681	14,545,207	3,786,619	821,580	962,682	--
Percent	9.46	25.94	47.58	14.24	2.31	0.39	0.03	0.01	100.00

TABLE 7. **Percent Frequency of Occurrence of Year Classes (Age Groups) per Stratum**

	Year class (age)							
	1972 (0)	1971 (I)	1970 (II)	1969 (III)	1968 (IV)	1967 (V)	1966 (VI)	1965 (VII)
Stratum 1 taken 9/29–10/16/72	2.05	21.49	60.34	15.18	0.94	----	----	----
Stratum 2 taken 10/16–11/1/72	1.06	23.09	62.43	12.87	0.55	----	----	----
Stratum 3 taken 11/1–11/7/72	2.20	18.66	60.54	16.67	1.73	0.20	----	----
Stratum 4 taken 11/7–11/14/72	0.89	11.47	60.71	23.06	2.13	1.53	0.21	----
Stratum 5 taken 11/15–12/18/72	6.70	33.41	51.51	7.72	0.66	----	----	----
Stratum 6 taken 12/19/72–4/5/73	8.93	33.25	40.84	14.22	2.56	0.19	----	----
Stratum 7 taken 4/5–4/10/73	5.47	6.74	38.78	30.22	16.19	1.92	0.36	0.33
Stratum 8 taken 4/10–4/16/73	18.16	22.40	38.24	17.92	2.65	0.63	----	----
Stratum 9 taken 4/16–4/26/73	10.40	28.56	44.37	13.66	2.30	0.71	----	----
Stratum 10 taken 4/26–5/1/73	13.82	26.57	39.15	16.57	3.65	0.23	----	----
Stratum 11 taken 5/1–5/6/73	11.41	32.36	39.02	14.72	1.80	0.68	----	----
Stratum 12 taken 5/6–5/11/73	17.88	34.37	37.91	8.84	0.77	0.23	----	----
Stratum 13 taken 5/11–5/15/73	22.37	34.82	35.10	6.52	1.19	----	----	----
Stratum 14 taken 5/15/73	20.39	23.67	46.57	7.83	1.54	----	----	----

throughout the season, although it decreased in numbers in the spring (Table 7). This same year class (1970) was prominent during the 1971–72 season when it comprised 51% by numbers and 46% by weight of the landings (Spratt 1973*b*). Numbers of age-group 0 fish became increasingly abundant in the spring as fish were recruited into the fishery (Table 7).

Age-groups I, II, and III contributed an estimated 88% by number and 87% by weight of the catch as compared to 80% by number and 88% by weight during 1971–72 season (Spratt 1973*b*).

Central California

Anchovies sampled in central California consisted mainly of age-group II (1970 year class), III (1969 year class), and IV (1968 year class) totalling 81% by number. These same year classes were also dominant during the 1971–72 season when they totalled 89% of the total catch by number (Spratt 1973*b*).

SEX AND WEIGHT RATIO

Southern California

Results of our sampling program showed a female to male numerical ratio of 1.98 : 1 and a weight ratio of 2.14 : 1 (Table 8). This is a sizeable departure from the 1971–72 season which had a female to male ratio of 1.3 : 1 by number and 1.6 : 1 by weight (Spratt 1973*b*). Collins (1969) noted wide variations of sex ratios from season to season and reasoned this to have resulted from higher proportions of females at older ages. Age-group II (1970 year-class) was the dominant age-group, with an increased proportion of females, and this may account for the variation (Figure 1). The female : male ratio was constant throughout most of the season, except during the last few strata when the ratio approached 1 : 1 (Table 8).

Central California

The female to male numerical sex ratio of anchovies from central California was 2.05 : 1 and was similar to that of southern California fish. Again, the larger percentage of older fish may have influenced the sex ratio, since there was a dominance of females in age-groups III, IV, and V (Figure 1). This ratio was a considerable change from 1971–72 season's ratio of 1 : 1, when the dominant age groups were I, II, and III (Spratt 1973*b*).

CONCLUSION

As previously reported by Spratt (1973*a*), the southern California anchovy reduction fishery has had no adverse effect upon the anchovy population. The past season's age composition data for southern California indicate a strong 1970 year class, with adequate recruitment of the 1971 and 1972 year classes. These findings suggest a relatively healthy southern California population.

Central California results show older fish in the fishery as has been noted in previous seasons (Collins 1969). Because the landings were light during the recent season, the fishery has had little effect upon the central California population.

TABLE 8. **Sex Ratio by Number and Weight of Anchovy Landings from San Pedro for 1972–73 Anchovy Reduction Season**

	By number			By weight (in kilograms)		
	Males	Females	Unknown	Males	Females	Unknown
Stratum I	60,255,887	161,317,749	60,095,352	982,924	2,709,064	844,864
% of total	21.32	57.42	21.26	21.67	59.71	18.62
Stratum II	72,239,308	196,018,227	30,928,979	1,089,216	3,042,132	400,384
% of total	24.15	65.52	10.34	24.04	67.13	8.84
Stratum III	91,653,025	161,189,244	36,591,016	1,404,331	2,582,706	477,951
% of total	31.67	55.69	12.64	31.45	57.84	10.70
Stratum IV	95,397,724	159,173,024	12,615,972	1,617,096	2,701,223	157,984
% of total	35.70	59.57	4.72	36.13	60.34	3.53
Stratum V	108,969,580	214,158,062	41,136,391	1,299,988	2,809,347	440,751
% of total	29.91	58.79	11.29	28.57	61.74	9.69
Stratum VI	57,144,593	200,712,200	12,787,453	840,345	3,573,200	167,523
% of total	21.11	74.16	4.72	18.34	78.00	3.66
Stratum VII	62,203,295	93,424,009	9,263,281	1,656,964	2,629,939	199,932
% of total	37.72	56.66	5.62	36.93	58.61	4.46
Stratum VIII	62,475,044	136,321,668	5,831,181	1,356,091	3,088,180	110,905
% of total	30.53	66.62	2.85	29.77	67.79	2.43
Stratum IX	59,497,058	130,775,284	20,008,355	1,217,023	2,886,795	346,355
% of total	28.29	62.19	9.52	27.35	64.87	7.78
Stratum X	79,415,603	136,390,778	13,873,468	1,497,556	2,754,112	235,088
% of total	34.58	59.38	6.04	33.38	61.38	5.24
Stratum XI	68,274,811	175,090,541	25,440,513	1,096,454	3,082,130	370,109
% of total	25.40	65.14	9.46	24.10	67.76	8.14
Stratum XII	88,582,153	179,572,360	10,359,427	1,253,836	2,858,996	142,120
% of total	31.81	64.48	3.72	29.45	67.21	3.34
Stratum XIII	132,322,038	154,453,766	21,751,701	1,860,314	2,402,253	269,705
% of total	42.89	50.06	7.05	41.05	53.00	5.95
Stratum XIV	39,892,502	43,624,261	7,249,217	524,934	768,440	90,506
% of total	43.95	48.06	7.99	37.93	55.53	6.54
Total	1,078,322,621	2,143,221,173	307,932,306	17,697,072 (39,015,571 pounds)	37,890,786 (83,535,321 pounds)	4,254,179 (9,378,908 pounds)
% of total	30.55	60.72	8.72	29.57	63.31	7.10

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CALIFORNIA CONDOR PLUMAGE AND MOLT AS FIELD STUDY AIDS[1]

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An analysis is made of the reliability of plumage and molt characteristics of the California condor for estimating age and identifying individual birds. Neither character seems sufficiently reliable to use in more than a general way.

INTRODUCTION

Identification of individual California condors (*Gymnogyps californianus*) and estimation of their age have been attempted on the basis of feather and head color changes and molt patterns (Koford 1953; Miller et al. 1965; Mallette and Borneman 1966). However, studies of a condor held captive in the Los Angeles Zoo raised questions concerning the validity of some of these criteria (Sibley et al. 1969; Todd and Gale 1970). A more complete analysis is presented in this paper.

The discussion that follows is based on three types of information: (i) observations of a captive California condor from the age of approximately 9 months until 6 years (Gale and Todd 1968; Todd and Gale 1970; Todd 1974); (ii) analysis of plumage and molt recorded in a series of photographs of wild condors; and (iii) plumage and molt data recorded in a series of approximately 3,000 observations of condors in the wild.

AGE DETERMINATION

California condors attain their adult plumage in approximately 5 years. Koford (1953) cites a number of zoo records to show that 4-year old birds are not adults, but 6-year olds are. At 5 years, the California condor at the Los Angeles Zoo still had some subadult plumage characteristics, but it would almost certainly have been classified as "adult" had it been seen under normal field conditions.

Koford (1953) recognized four immature plumages, which he assumed represented four year classes. The first year, or juvenal plumaged bird, is characterized by a predominantly white underwing patch with a prominent black axillar spot, a slight gray stripe on the upper surface of the wings (formed by gray edging on the upper greater secondary coverts), and a downy black head. In the second, or immature, stage, the plumage is decidedly black overall with no markings on the secondary coverts and only minor mottling of white in the underwing patch. The head is still black and downy. In the third, or "ringneck", stage, the plumage is even darker, but the lower neck begins to color a pinkish-gray, producing a conspicuous ring of color. In subadult

[1] Accepted July 1974.

plumage, the head and neck have turned orange and adultlike, the underwing patches are white except for a prominent dark axillar spot, and a conspicuous white bar begins to form on the upper wing surface. The black spotted axillar feathers are eventually lost, and the bird gradually assumes ''full adult'' coloration.

Although there is a general pattern of plumage change among wild birds, most do not fit completely into any of the above age categories (Table 1). Development of the upperwing stripe appears particularly variable, as does the presence of the axillar spot. Most birds in juvenal plumage are conspicuously white under the wings, but there are exceptions. For instance, Observation 13 (Table 1) was definitely a condor hatched the previous summer and still associated with the nest site, yet its overall coloration was more nearly that of an ''immature'' (2-year old) bird. The condor of Observation 16 was extremely dark, but its location and behavior strongly suggests that it was only 1 year old.

TABLE 1. **Variation of California Condor Plumages**

Observation number	Probable age*	Age class characters†				
		Wing patch	Axillar spot	Upperwing stripe	Head and neck	Composite
1	9 mo	B	B	--	A-B	B
2	2 yr	B	B	A	A-B	A-B
3	3 yr	D	C	--	A-B	B-D
4	1 yr	A-B	A	--	A-B	A-B
5	1 yr	B	A	--	A-B	A-B
6	9 mo	A	A	--	A-B	A
7	3–4 yr	B	A, D	A, D	C	B-D
8	6 mo	A	B	--	A	A-B
9	9 mo	A	B	--	A-B	A-B
10	2 yr	B-C	B-C	--	A-B	B-C
11	9 mo	A	A	--	A	A
12	+1 yr	A	B	A, D	A-B	A-B
13	9 mo	B	B	--	A-B	B
14	2–3 yr	C	A, D	--	B	B-C
15	2 yr	B	B	A, D	B	A-B
16	1 yr	B-C	B-C	B-C	A-B	B-C
17‡	1½ yr	A	A	A	A	A
18‡	2½ yr	A-B	B	A	B	A-B
19‡	3½ yr	B-C	C	D	C	B-D
20‡	4½ yr	D	D	D	C	C-D

* Based on behavior (flying ability, association with parents) and location.
† A = juvenal; B = immature; C = ringneck; D = subadult; after Koford 1953.
‡ Known-age captive bird.

Another problem is illustrated by the following diary entry I made for August 3, 1972, describing a bird believed hatched in the area in 1971: ''Underwing patches were almost striped—very deceptive, because they appeared almost solid white when it left its perch, but very dark when overhead.'' This bird seen on two separate occasions might have been classified as two birds of different age.

It thus appears that there is too much variation in developmental plumages to permit precise age determination. Similar variation has been noted in gannets (*Sula bassana*) (Nelson 1966), goshawks (*Acci-*

piter gentilis) (Sushkin 1928), golden eagles (*Aquila chrysaetos*) (Jollie 1947), bald eagles (*Haliaeetus leucocephalus*) (Southern 1964), and others. A general rule seems to be that the longer the period of immaturity in a species, the greater is the individual variation to be expected (Brown and Amadon 1968). Despite variation, condors apparently can be readily separated into "immatures" (1–3 years approximately), "ringnecks" (3–4 years), and "subadults" (4–5 years) on the basis of general coloration. First-year birds are best identified on the basis of behavior and locality, considering such things as weak and erratic flight, close association with parent birds, and proximity to known nest sites.

IDENTIFICATION OF INDIVIDUALS

Richford and Stewart (1973) based a population estimate of the black vulture (*Aegypius monachus*) on the frequency and location of sightings of birds with distinctive plumage irregularities. McGahan (pers. comm) used missing feathers and distinctive head markings to separate individual Andean condors (*Vultur gryphus*). California condor observers have also used prominent feather gaps and distinctive subadult plumages (Mallette and Borneman 1966). The usefulness of various criteria for condors is analyzed below.

Molt

Koford (1953) noted that California condors have been observed with some of their major feathers (primaries, secondaries, retrices) missing during every month of the year. He could not determine a major period of molt, but he found many freshly-molted feathers around condor roosts in March and in summer, and seldom saw condors with missing feathers in December. My field notes and a selection of photographs of condors indicate a definite molting period extending from March through October. Very few birds observed from November through February have missing flight feathers. The captive condor referred to earlier has also shown a definite molt period, extending from May through September.

Koford (1953) suggested that a complete molt might require more than 1 year, and this was borne out by the plumage development records for the captive condor. Approximately one-half of its primary feathers were molted each year, sequentially from the innermost to the outermost, and essentially synchronous on the two wings. Birds observed in the wild show a comparable symmetry. Widely separated missing primaries (e.g., a number 2 primary and a number 7 primary) may be the result of accidental loss (Koford 1953).

The molt of secondaries and retrices occurs during the same general season as primary molt, but feathers appear to drop more or less at random. The captive bird retained some secondaries for several years. The usual situation in the wild is unknown.

Koford (1953) observed that one primary feather on a recognizable wild condor took over 1 month to grow. The primaries of the captive condor took up to 2 months to attain full development.

Missing feathers offer some opportunity to identify individual condors, particularly during the peak of molt in summer and early fall. Because the spread primaries of a condor are easily seen and enumerated, identification of missing or growing feathers can be relatively

free from error. Feather growth requires a month or more, so it may be possible under some circumstances to distinguish a particular bird for that length of time. Because primary molt is normally sequential some groups of birds can be separated from others over a longer period. For example, a condor seen in July with the 7th primary short and the 8th primary missing is not likely to be any of the birds seen earlier in the summer with any of the first four or five primaries missing or growing. Secondaries and retrices are much more difficult to identify correctly under field conditions, and their irregular molt reduces their value for identification purposes.

Because molt is limited seasonally and is well ordered, many condors are likely to be at the same stage of primary molt simultaneously. For instance, many condors will be missing primaries 1, 2, or 3 in April, or primaries 5, 6, or 7 in June. I have a photograph taken in June of two adult condors that have identical feather gaps in both primary and secondary areas of their right wings. (The left wings are not in view in the photo.) If these birds were observed separately, there is a good possibility that they would be identified as the same condor. All things considered, it appears that identifications based on molt alone are subject to considerable error.

Plumage Coloration

All adult California condors appear almost identically colored, even at extremely close range. The various subadult plumages described above offer some opportunities for individual identification, especially when unusual plumages also include conspicuous feather gaps. However, certain color patterns can appear deceptively different due to light and position.

Also, different condors can be very similar in appearance. For example, on May 31, 1972 I observed three subadults simultaneously, two of which were virtually identical. These would almost certainly be recorded as the same bird if viewed separately. Southern (1963) observed two seemingly identical immature bald eagles simultaneously, and noted a number of other birds having similar plumages. He cautioned against using "unusual" plumages to identify individual birds.

Head and Neck Characteristics

McGahan (pers. comm.) was able to distinguish some individual Andean condors by head characteristics. In that species, males have a distinct caruncle, and all have various skin flaps and "warts" that form unique patterns when seen at close range. The California condor, however, has no obvious external sexual characteristics and is relatively smooth headed. I have noted some differences in the brilliance of head and neck coloration, and in the degree of "puffiness" of checks and neck. However, these features are only useful for limited periods at extremely close range.

ACKNOWLEDGMENTS

For this analysis, I used the field observations of many individuals, particularly those of J. C. Borneman, W. D. Carrier, and F. C. Sibley. Sibley and F. S. Todd made most of the observations on the captive condor. Borneman, Carrier, Todd, and R. D. Mallette reviewed the manuscript.

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NOTES

OCCURRENCE OF THE RARE NORTH PACIFIC FROSTFISH, *BENTHODESMUS ELONGATUS PACIFICUS* PARIN AND BECKER, 1970, IN MONTEREY BAY, CALIFORNIA

On July 5, 1968, while fishing off Sandholt Pier in Moss Landing, California, a fisherman, Ramon Castillo, hooked a 1020 mm (40.2 inch) Standard Length (SL) North Pacific frostfish, *Benthodesmus elongatus pacificus* Parin and Becker, 1970, a species unknown in California (Figure 1). This interesting deep-water fish was brought to the Moss Landing Marine Laboratories and placed unidentified in the ichthyology research collection. During the summer of 1973, while reorganizing this collection, we rediscovered this specimen along with another slightly smaller individual that had no collection data, and identified both of them as *Benthodesmus simonyi,* using keys to the family Trichiuridae (Tucker 1956) and to the genus *Benthodesmus* (Tucker 1953). The specimens did not fit Tucker's descriptions well, however, differing in the number of vertebrae by 8 through 10 and the number of dorsal fin elements by 8 or 9. Further investigation led to the identification of these specimens as *B. elongatus pacificus* (family Trichiuridae) according to Parin and Becker (1970). We have chosen to follow the familial designation of Tucker (1956) and Parin and Becker (1970), even though fishes in the family Trichiuridae are closely related to those in the family Gempylidae, members of which also occur in California waters (Fitch and Lavenberg 1968; Miller and Lea 1972).

FIGURE 1. *Benthodesmus elongatus pacificus* (CAS 29300; 1020 mm SL). Left side of head (135 mm HL). *Photograph by Gary McDonald, April 1974.*

The taxonomic history of the genus *Benthodesmus* is confusing (Goode and Bean 1881; Steindachner 1891; Maul 1953; Tucker 1953, 1956) and it appears that much of this confusion resulted from the lack of widely distributed comparative material. Parin and Becker (1970) assigned the new subspecific designation, *Benthodesmus elongatus paci-*

ficus, to five specimens from the western North Pacific collected by the Soviet trawler R/V Vityaz from 1958 to 1966, one specimen off Japan (Franz 1910), and one specimen off British Columbia (Gilbert 1917). Thus, these two specimens from Moss Landing not only add a new species to the California marine fish fauna but represent the second and third recorded collections in the eastern North Pacific Ocean. The first specimen, considered by Hart (1973) to be lost, was discovered on loan to Scripps Institution of Oceanography and is now being returned to the British Columbia Provincial Museum.

The meristic and morphometric counts and measurements for the two specimens (Table 1) are similar to those given by Franz (1910), Gilbert (1917), and Parin and Becker (1970). This sixth California trichiurid can be distinguished from all other family members by the prominent symphyseal knob and the separate spinous and soft portions of the dorsal fin with its higher count of fin elements. Even though our specimens had been in formalin, the otolith morphology (Figure 2) differs from those described by Fitch and Gotshall (1972) in that the antirostrum (see Frizzell and Dante 1965) is not greatly pointed forward, the ventral surface of the otolith is more rounded than any other California trichiurid, and the greatest height of the otolith occurs along the middle third where the dorsal and ventral profiles are parallel.

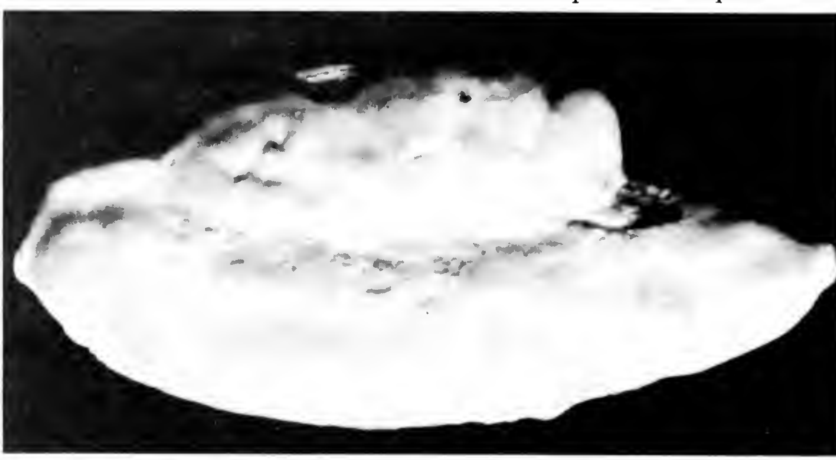

FIGURE 2. Left sagitta (otolith) from *Benthodesmus elongatus pacificus* (7.0mm) (CAS 29300). *Photograph by Gary McDonald, April 1974.*

The two specimens of *Benthodesmus elongatus pacificus* collected off Moss Landing are deposited in the ichthyology collection of the California Academy of Sciences (CAS 29300 and CAS 30692).

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We would like to thank John Fitch, California Department of Fish and Game, for reviewing a rough draft of the manuscript, and James Gordon, California Academy of Sciences, for providing radiographs from which all counts were made.

TABLE 1. Meristics and Morphometrics on Monterey Specimens of *Benthodesmus elongatus pacificus*

Measurements	CAS 30692			CAS 29300		
		% of SL	% of HL		% of SL	% of HL
Total length	1148 mm	102.4	----	1020 mm	102.2	----
Standard length	1121 mm	----	----	988 mm	----	----
Head length	149 mm	13.3	----	135 mm	13.6	----
Bony interorbital space	23 mm	2.1	15.4	22 mm	2.2	16.3
Snout length	62 mm	5.5	41.6	53 mm	5.3	39.3
Orbit diameter	23 mm	2.0	15.4	26 mm	2.6	19.3
Maxillary length	50 mm	4.5	33.6	50 mm	5.0	37.0
Depth caudal peduncle	2.6mm	----	.2	2.4mm	----	.2
Body depth at pectoral origin	51 mm	4.5	34.2	42 mm	4.2	31.1
Predorsal length	132 mm	11.5	88.6	122 mm	12.0	90.4
Preanal length	466 mm	40.6	312.8	419 mm	41.1	310.4
Dorsal fin elements	146			145		
Anal fin elements	i+1+93			i+1+91		
Pectoral fin rays*	12			12		
Branchiostegals	7			7		
Lateral line pores	237†			238†		
Vertebrae	148			150		
Gill rakers	5+1+8=14			5+1+8=14		

* There are no pelvic ray counts in these specimens because they are fused in both to form a minute spatula-shaped scute.
† These counts are approximate as the lateral tissue was often bruised or missing in both specimens.

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A RANGE EXTENSION AND TWO NEW CALIFORNIA SIZE RECORDS FOR MOLLUSKS

On May 15 and June 29, 1973, Department of Fish and Game biologists collected several specimens of the snail *Terebra pedroana* (Figure 1) while conducting a survey to locate a man-made reef site offshore from Channel Islands Harbor, Ventura County. The bottom depth at this location (approximately 119° 15.8′W, 34° 9.0′N) is 18.3 m (60 ft). The bottom was muddy sand with a 0.5–1.0 mm (0.02–0.04 inch) layer of surface silt. The snails were observed plowing through this upper layer with the foot and lower body beneath the surface.

Many authors give the northern range limit of this snail as San Pedro, California (McLean 1969, Morris 1952, Oldroyd 1927); however, Abbott (1954) gives the northern limit as Redondo Beach, while Turner, Ebert and Given (1969) describe *T. pedroana's* presence at Hermosa Beach and Santa Monica. I searched through unpublished Department of Fish and Game diving logs and noted that *T. pedroana* was observed offshore from Zuma Beach in 1963.

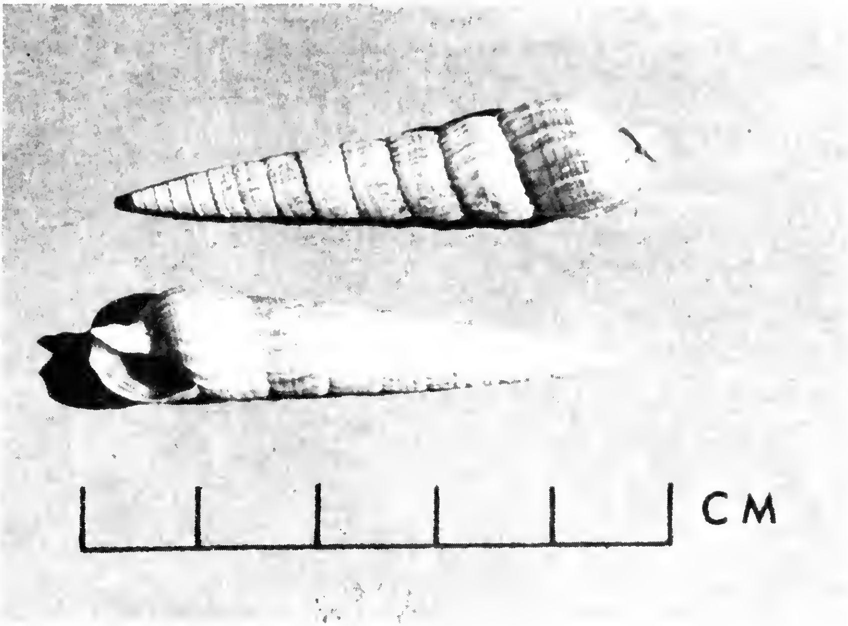

FIGURE 1. A 4.5 cm (1.8 inch) snail, *Terebra pedroana*, taken offshore from Channel Islands Harbor. Photograph by John M. Duffy.

The Ventura County specimens represent a range extension of 64.3 km (40 miles) northeast of their published northern range (Santa Monica) and 40.2 km (25 miles) northeast of their northernmost observed location (Zuma Beach).

On April 23, 1969 while conducting a survey offshore from San Mateo Point, Orange County, California, (117° 30.6′W, 33° 20.3′N), Department biologists noted the presence of clipped semeles, *Semele decisa,* and sunset clams, *Gari californica.* We dug out a 1 m^2 (10.9 ft^2) quadrat in the cobble rock bottom at a depth of 10.7 m (35 ft). This cobble bed is an offshore continuation of intertidal areas known to contain large numbers of bivalves (Fitch 1953). Common littleneck clams, *Protothaca staminea,* are the most abundant clam in the intertidal zone. Other bivalves common there are clipped semeles, sunset clams, common Washington clams, *Saxidomus nuttalli,* and gaper clams, *Tresus nuttalli.* We dug to a depth of about 30 cm (11.8 inches) and recovered 13 clipped semeles and 24 sunset clams (Figure 2). I saved the shells of the largest specimens for measurements. The largest clipped semele was 106 mm (4.2 inches) in length and the largest sunset clam was 134 mm (5.3 inches) in length.

Fitch (1953) gives the maximum length of both species as 101.6 mm (4 inches). Coan (1973 a, b) gives a maximum size of 115 mm (4.5 inches) for *G. californica* and 94 mm (3.7 inches) for *S. decisa.* While examining specimens at the Natural History Museum of Los Angeles County (LACM), I noted a clipped semele (LACM 67–70) which was 110.5 mm (4.4 inches) in length and a sunset clam (LACM 67–44)

which was 140.5 mm (5.5 inches) long. Both of these shells were from Mexican waters.

Even though scientific scuba diving is nearly 20 years old, it is evident that much remains to be learned of subtidal biological communities. These clams are not susceptible to such collecting gear as dredges and grabs and their presence may not be readily noted by divers. Even in areas where large numbers of dead shells are seen, casual digging will not always locate live clams. Thus, as interest in these animals grows, we may expect to see more size records and range extensions of mollusks which have previously been sampled only by dredges, grabs or intertidal digging.

Specimens of *Terebra pedroana* and the *Semele decisa* and *Gari californica* have been deposited with the LACM for accession into their invertebrate collections.

FIGURE 2. Sunset clams, *Gari californica*, and clipped semeles, *Semele decisa*, from a 1 m^2 quadrat offshore from San Mateo Point. Photograph by Alec R. Strachan.

ACKNOWLEDGMENTS

I wish to acknowledge the late Charles H. Turner's diving assistance and guidance in learning how to recognize subtidal bivalve communities. Former Department of Fish and Game employees Alec R. Strachan and Richard L. Moe also provided diving assistance. James H. McLean (LACM) confirmed the identification of *Terebra pedroana*. Gale Spohn, also of the LACM, allowed me to examine specimens of *S. decisa* and *G. californica*. John E. Fitch, California Department of Fish and Game

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OCCURRENCE OF THE FATHEAD MINNOW, *PIMEPHALES PROMELAS*, IN OREGON

A collection of fish (OS4944) from Spencer Creek, Klamath County, Oregon on 13 May 1974 included 19 fathead minnows. This is the first reported occurrence of this species in Oregon.

The fish were collected with a battery powered electroshocker in Spencer Creek 100 m (110 yards) upstream from its confluence with the Klamath River at Camp Sa-wa-li-na-is. Water temperature was 11.5 C (53 F). Other fish collected at the same location were the Klamath smallscale sucker, *Catostomus rimiculus;* Pacific lamprey (ammocotes), *Entosphenus tridentatus;* speckled dace, *Rhinichthys osculus;* and rainbow trout, *Salmo gairdneri.* The collection site is about 27 km (17 miles) southwest of Klamath Falls, Oregon. Five km (3 miles) downstream, about 24 km (15 miles) north of the Oregon-California border, the Klamath River is impounded by Boyle Dam, creating Boyle Reservoir. I sampled 5 km (3 miles) further upstream that same day but did not collect any other fathead minnows. Dean Ahrenholz (Calif. Dept. Fish and Game, pers. comm.), while sampling in Boyle Reservoir on 25 May 1974, observed schools of fathead minnows around emergent vegetation. The males he examined had obvious tubercles on their heads and the females were very heavy bodied; apparently he observed a spawning congregation.

The identification of the fish I collected was based on 9 males and 10 females and was confirmed by the use of several keys and by comparison with specimens of *P. promelas* in the Oregon State University collection (OS 3036, Alberta, Canada; and OS 4203, Kansas). Char-

acters used for identification included: dorsal rays 8 (19); anal rays 7 (19); lateral line incomplete (19); lateral scale counts, for females the average was 42, for males, 45. The standard length of females ranged from 44 to 50mm (1.75 to 2.0 inches), males from 47 to 52mm (1.85 to 2.1 inches). None of the males showed any tubercle or dorsal-pad development.

Presumably, the minnows were introduced by fishermen using live bait. Angling with live fish is prohibited in Oregon but from personal observations during March through May, 1974, I concluded that the practice was widespread in southern Oregon. These minnows have not been reported from the Klamath River in California (Ahrenholz, pers. comm.) but there are established populations in the Central Valley of California (Kimsey and Fisk 1964) and at other locations in northern California (Dr. Peter Moyle, U.C. Davis, pers. comm.). Contreras (1973) lists *P. promelas* from the Lost River system in California-Oregon. However, there is some doubt concerning his reported record. Contreras lists fathead minnows as being collected below Anderson-Rose Dam (Oregon) about 5 km (3 miles) above the Oregon-California border. The report (Koch and Contreras 1973) from which his thesis is drawn does not include fathead minnows in the list of fish collected at that same collecting station.

Scott and Crossman (1973) regard the fathead minnow as a highly desirable forage fish. Its food requirements appear to be very similar to native minnows and suckers. The effect of competition by *Pimephales promelas* on the native fish fauna of the lower Klamath basin is unknown at this time.

ACKNOWLEDGMENTS

This work was completed while I was conducting field studies supported by the U. S. Fish and Wildlife Service. Dr. Carl Bond confirmed the identification of the fish and reviewed the manuscript.

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LATITUDINAL RANGE EXTENSIONS FOR YELLOW AND SPOTTED SNAKE EELS (GENUS *OPHICHTHUS*)

On January 8, 1971, a badly deteriorated yellow snake eel, *Ophichthus zophochir,* Jordan and Gilbert, was recovered from an intake filter screen at the Pacific Gas and Electric Atomic Power Plant, Humboldt

Bay, California (lat. 40° 48′N, long. 120° 11′W). Prior to the disposal of the remains, the identification of this specimen was verified through examination of the otoliths and dentition. The recovery, incorrectly cited as *O. triserialis* (Miller and Lea 1972), extends the previous northern geographical limit for this species (Hopkirk 1965) by approximately 290 km (180 miles).

A spotted snake eel, *O. triserialis*, kaup, was captured October 28, 1972, by the Department's research vessel *N. B. Scofield* during trawling operations 2.9 km (1.8 miles) WSW of the Klamath River (lat. 40° 32′N, long. 124° 6.8′W) in depths of 22 to 24 m (27.6–79.2 ft). The recovery extends this species previous northern limit (Hopkirk 1965) by approximately 354 km (220 miles). The 900 mm (35.4 inch) total length (TL) specimen was a sexually immature female fish whose otoliths (sagittae) showed five clearly marked winter zones (John E. Fitch, pers. comm.).

The spotted snake eel was deposited in the fish collection of the Natural History Museum of Los Angeles County.

ACKNOWLEDGMENTS

We would like to express our thanks to John E. Fitch for providing vital information on both specimens and to Daniel W. Gotshall for his suggestions on organizing this note.

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—*Lawrence F. Quirollo and Paul A. Dinnel, Marine Resources Region, Department of Fish and Game, Eureka, California 95501. Mr. Dinnel's present address is Fisheries Research Institute, University of Washington, Seattle, Washington 98105.* *Accepted December 1974.*

OCCURRENCE AND DEPTH RANGE EXTENSION OF THE YELLOW SNAKE EEL *(OPHICHTHUS ZOPHOCHIR)* OFF SOUTHERN CALIFORNIA

On February 14, 1974 a 562 mm (22.1 inch) yellow snake eel, *Ophichthus zophochir* (Jordan and Gilbert), was taken by members of Marine Biological Consultants, Inc., and the biological staff of the County Sanitation Districts of Orange County during a trawling survey offshore of Newport Beach.

The specimen was captured in a 7.3-m (24-ft) otter-trawl with 3.8-cm (1.5-inch) bar mesh in the wings and throat, and 1.3-cm (0.5-inch) bar mesh in the cod end during a 10 min drag at 1.5 to 2.0 knots from the *Vantuna*, a research vessel operated by a consortium of southern California colleges and universities.

The station was 1.1 km (0.67 mile) SW of the end of the Balboa Pier in 64 m (210 ft) of water. Capture at this depth constitutes sub-

stantial increase in reported depth range, which is said to be from the intertidal region to about 18.2 m (60 ft) (Miller and Lea 1972*a*). Geographically, this species ranges from off Eureka, California, to Peru, including the Gulf of California (Miller and Lea 1972*b*). However, it is considered "rare" in local waters by Miller and Lea (1972*a*) which means by their definition that 20 or fewer individuals have been taken in California.

The rest of the catch consisted of 261 specimens of *Microstomus pacificus,* 110 *Porichthys notatus,* 58 *Lycodopsis pacifica,* 46 *Symphurus atricauda* and five or less of eight other species.

This specimen was given to John Stephens at Occidental College who verified the identification and requested its acquisition for the ichthyological collection.

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—*John Wintersteen, Marine Biological Consultants, Inc., 947 Newhall Street, Costa Mesa, California 92627.* *Accepted December 1974.*

A PARAKEET AUKLET, *CYCLORRHYNCHUS PSITTACULA,* FROM MONTEREY BAY, CALIFORNIA

On 3 March 1974, I found a dead parakeet auklet on the beach 4 km (2.5 miles) north of Moss Landing, in Monterey Bay, California. Although the parakeet auklet is recorded as a sporadic winter visitant off the California coast (Grinnell and Miller 1944), this specimen represents the first record from California in over 30 years (Storer 1944), and the first record from Monterey Bay since 1908 (Beck 1910).

The beach-cast specimen, an adult molting into nuptial plumage, was in fresh condition. A large patch of oil on the auklet's breast was the apparent cause of death. This specimen has been deposited in the vertebrate collection at the Moss Landing Marine Laboratory (accession number 4896).

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—*Larry G. Talent, Moss Landing Marine Laboratories of the California State Universities, Moss Landing, California 95039.* *Accepted for publication October 1974.*

FIGURE 1. Portion of one group of bat rays, *Myliobatis californica* Gill. Photograph by Richard L. Moe.

AN UNUSUAL AGGREGATION OF BAT RAYS, *MYLIOBATIS CALIFORNICA* GILL

On August 27, 1973, at approximately 0900, Richard L. Moe and I observed an unusual aggregation of bat rays, *Myliobatis californica* Gill, approximately 0.8 km (0.5 mile) offshore of the Palos Verdes Peninsula, Los Angeles County, California. We observed the rays in the area between White's Point and Point Vicente, moving in a westerly direction at one point, and later, moving in an easterly direction along the peninsula.

We skin dove on several groups of rays, which were swimming between 1.5 and 6 m (5 and 20 ft) below the surface. Richard L. Moe took a series of photographs, one of which is included (Figure 1). The groupings consisted of from 5 to 100 individuals, and we estimated the total number of individuals to be in the thousands. All the rays were of the same general size, approximately 300 mm (12 inches) in "wingspan." The groups took evasive action as a group when pressed closely by the divers.

ACKNOWLEDGMENTS

I wish to thank Richard L. Moe for his photographs and assistance, since his isolation in the Antarctic makes it impossible for him to review, and thus co-author this note.

—*Dan B. Odenweller, California Department of Fish and Game, 3900 N. Wilson, Way, Stockton, California 95205.* *Accepted October 1974.*

PUGHEADEDNESS IN THE LONGSPINE COMBFISH, *ZANIOLEPIS LATIPINNIS*, FROM MONTEREY BAY, CALIFORNIA

On 5 November 1970, I captured a pugheaded longspine combfish, *Zaniolepis latipinnis*, in an otter trawl, at a depth of 61 m (201.3 ft), 9.6 km (5.8 miles) west of Moss Landing, in Monterey Bay, California. Although pugheadedness is well documented in fishes (Dawson 1964, 1966; Rose and Harris 1968; Bortone 1971; Valentine and Samollow 1973), this specimen represents the first record of pugheadedness in longspine combfish.

The pugheaded specimen has a much shorter head and upper jaw than typical longspine combfish (Figure 1). Comparative skeletal analysis of the pugheaded specimen and a non-pugheaded specimen of similar size, cleared and stained according to the methods described by Taylor (1967), and Miller and Van Landingham (1969), revealed several deformities (Figure 2). Measurements, taken in accordance with the definitions of Hubbs and Lagler (1964), are presented in Table 1. The pugheaded specimen exhibits a shortened and thickened parasphenoid with a calcified knob projecting dorsally, ventrally projecting maxillaries, orbits that are obliquely elongate, and dorsal arching of the frontal bones. All bones are present and except for the parasphenoid are relatively typical in size. No other abnormalities are obvious except for a bifurcation of the second dorsal spine (Figure 1).

It appears that the pugheaded condition in this specimen could be a result of differential growth of the parasphenoid. A parasphenoid

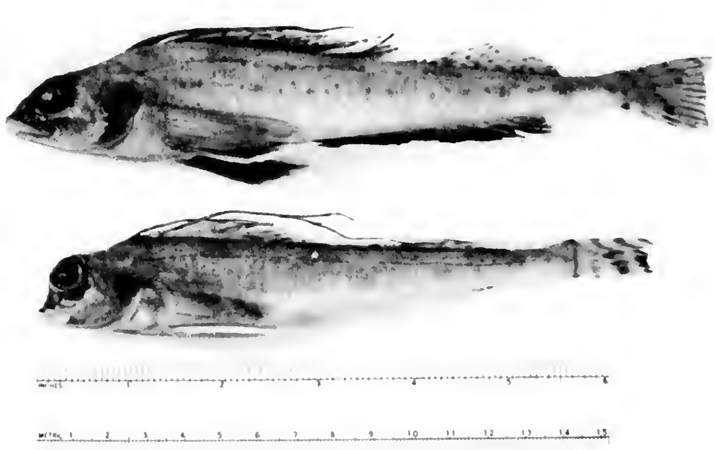

FIGURE 1. A non-pugheaded longspine combfish, *Zaniolepis latipinnis*, (above), and pugheaded specimen (below). Photograph by G. E. Kukowski.

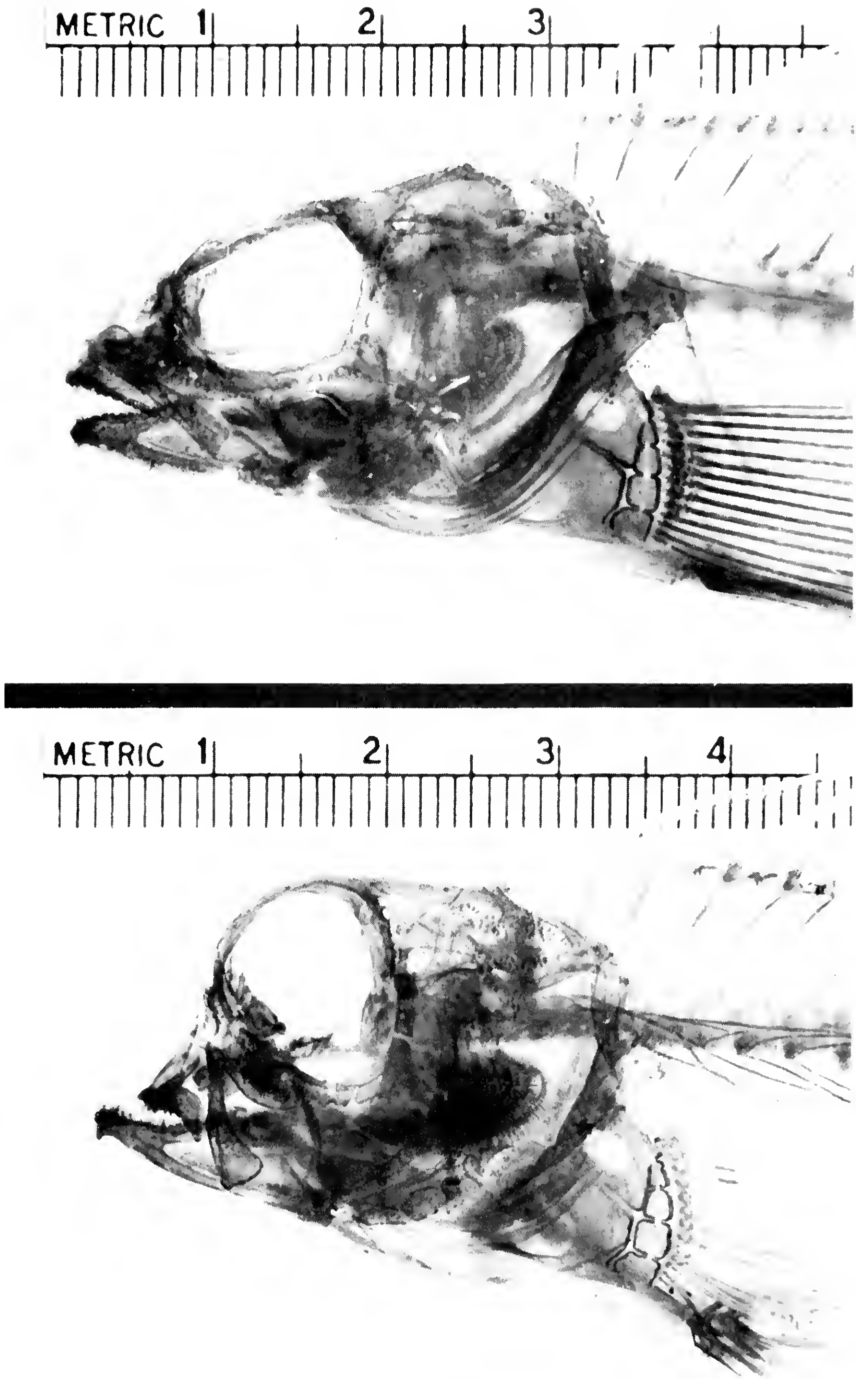

FIGURE 2. Cleared and stained longspine combfish, *Zaniolepis latipinnis;* non-pugheaded specimen (above) and pugheaded specimen (below).

TABLE 1. **Measurements of a Pugheaded and a Non-Pugheaded Specimen of Longspine Combfish, *Zaniolepis latipinnis*.**

Measurement	Percent of standard length	
	Non-pughead	Pughead
Standard length (mm)*	143	145
Depth of head	12.9	15.3
Head length	23.8	19.1
Head width	11.9	11.8
Height of cheek	8.5	8.3
Least bony interorbital width	3.0	2.9
Length of cheek	15.3	10.2
Length of mandible	10.2	9.8
Length of orbit	7.8	8.4
Length of upper jaw	9.2	6.8
Orbit to angle of preopercle	5.5	5.5
Postorbital length of head	11.3	8.8
Predorsal length	22.5	19.5
Snout length	5.8	5.2

* Measured from anterior tip of lower jaw to caudal base.

that grew relatively slower than other bones of the head would have a drawstring effect on the snout and could cause most abnormalities exhibited by the pugheaded specimen. However, there is no way to know with certainty whether the deformities are developmental or congenital.

ACKNOWLEDGMENTS

I thank Gregor Cailliet and Peter Moyle for reading the manuscript.

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—*Larry G. Talent, Moss Landing Marine Laboratories of the California State Universities, Moss Landing, California 95039.* *Accepted December 1974.*

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FISH AND GAME COMMISSION

NOTICE IS HEREBY GIVEN that the Fish and Game Commission will meet on June 27, 1975, at 9:00 a.m. in the Elks' Lodge, 151 E. Line Street, Bishop, California, to receive recommendations from its own officers and employees, from the department, and other public agencies, from organizations of private citizens, and from any interested persons as to what, if any, orders should be made relating to resident game birds for the 1975–76 hunting season.

Notice is also given that the Fish and Game Commission will meet on August 15, 1975, at 9:00 a.m. in Room 1194 of the State Building, 455 Golden Gate Avenue, San Francisco, California, to hear and consider any objections to regulations proposed for resident game birds for the 1975–76 hunting season.

This notice is published in accordance with the provisions of Section 206 of the Fish and Game Code.

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